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THE PAST AND THE FUTURE OF THE MEDICAL SCIENCES IN THE UNITED STATES[1]

AT the 1919 meeting of the American Association for the Advancement of Science, held in St. Louis, the association adopted a new constitution which included among other modifications a change in the name of this section from "Physiology and Experimental Medicine" to "Medical Sciences." In the same year, the National Research Council of the United States in effecting its "permanent organization" on a peace time basis changed the name of its "Medical Division" to "Division of the Medical Sciences." Thus in a single year the term "Medicine" disappears as the substantive from the titles of what may fairly be regarded as the two most important organizations on the continent whose main function it is to further the interests of science in general and to stimulate research, to yield up its primary position to one secondary in importance to the term science. There can be no doubt but that these changed designations are indicative of a changed attitude in the United States toward medicine as a science, and it therefore seemed fitting that the first chairman of the section thus newly designated upon retiring from office should essay an analysis of the factors that seem to him to be responsible for the change, in an effort to ascertain the significance of the implied trend. An additional reason for selecting this general topic for discussion is the rather unusual and intimate insight into the conditions at present prevailing in the departments of the medical sciences in the United States which the speaker was enabled to gain through his connection with a study of the supply of assistants in pre-

[1] Address of the vice-president and chairman of Section N—Medical Sciences, American Association for the Advancement of Science, Toronto, December, 1921.

clinical departments, carried out under the auspices of the National Research Council.

The statements from the laboratories of the country collected for the purposes of that investigation have been analyzed elsewhere with a view to securing from them the information relating to the question then in hand. But they contain in addition a wealth of material bearing on the broader topics of the present status and future prospects of the medical sciences in this country which this paper proposes to discuss. From this material the speaker has drawn freely in developing certain of the phases of his subject; owing to the circumstances of its collection, though, it has not been possible always to indicate to whom credit is due. And finally, it should be added that the views to which expression is given in this address may apply best, possibly only, to the branch of science in which the speaker himself works, namely physiology, and with which he consequently has a certain degree of familiarity. He is inclined to believe, though, that they will apply to the other medical sciences also; to some rather closely, to others perhaps somewhat more remotely.

In order to gain a vantage point from which to survey the field of medical science as it has been cultivated in the United States and from which to ascertain the direction in which it is moving, it becomes necessary first to trace in a cursory way the development of the subject from its beginning down to the establishment of its modern trend. Contributions to science have been made ever since man acquired the ability to hand on his experiences with nature; but in the case of medical science, at least, such advances as were made down to the fourteenth century were upon the whole unimportant, and for the most part casual. It should be borne in mind, though, that whatever of value was then gained formed the basis upon which subsequent advances were built. Every now and then these occurred in rapid sequence through the efforts often of single individuals or of groups of individuals stimulated by an innate desire to ascertain the relation between cause and effect, and endowed with the genius to see those relations.

With the revival of learning in Italy systematic studies by the scientific method here and there began to be made of the more obvious of the natural phenomena. The structure of the human body mainly, but occasionally its functions also, both normal and abnormal, collectively then known under the name of anatomy, and the structure of the universe were amongst the first of the problems to be attacked with any degree of success. At this time, and indeed in one and the same year, there appeared the *"De revolutionibus orbus cælestrum"* of Copernicus and the *"De corporis humani fabrica libri septem"* of Vesalius, the epoch making works in their respective fields; medical science and physical science employing in effect the same methods are here seen advancing together as they have ever since, because of their related habits of thought and their mutual helpfulness. Progress in the experimental phases of medical science, however, was slow. The faint glimmer of light in this direction that became discernible during the Renaissance, in the succeeding four centuries every now and then broke forth momentarily into a brighter flash when some keener intellect such as Harvey, Malpighi, Mayow, Boyle, Haller, Hales, Spallanzani, Hewson, Lavoisier, Wolff, Hunter, Young, Morgagni and others, gentlemen of leisure, clergymen, lawyers, physicians, rarely scientists by vocation, compelled by an inborn spirit of inquiry and working for the most part in private laboratories, made brilliant contributions to the slowly and sporadically growing accumulation of medical science.

Partly in consequence of the rapidly widening confines of knowledge, but especially as a result of the recognition of underlying differences in technical methods, a tendency to separate the functional from the structural phases began to develop, the former leading to physiology, the latter retaining the designation, anatomy. At about the same time, a distinction began to be more clearly drawn between the normal and the abnormal, both in structure and in function, and a tendency to appreciate more fully the value of organic chemistry in the study of biological phenomena became obvious; although biological chemistry came to be recognized as a distinct science at a

somewhat later period. It would seem, however, that there is no simple formula that is sufficiently general to account fully for the sequence in which the independence of the several medical sciences became established.

Toward the close of the first quarter of the last century, this sporadic and localized growth of medical science became more consistent and eventually general, though still somewhat uneven, throughout the whole of western civilization. The initiative in this new growth is attributed mainly to the influence of two men, viz., Johannes Müller, professor of anatomy and physiology at Bonn and Berlin from 1830 to 1858, and François Magendie, professor at the Collège de France from 1836 to 1855; and it was fostered by a recognition of the fact that medicine is nothing more nor less than a part of science. I do not believe, however, that I am mistaken when I maintain that in previous epochs of the history of science there have been individuals, even groups of individuals, who have employed the experimental method, and quite as successfully, to advance medicine, and who have regarded medicine in exactly the same light. It would seem, therefore, that some new and fructifying influence must at this time have been brought to bear upon such efforts as were being made toward progress. Why, we might ask in this connection, did the new growth develop more vigorously in Germany than in France? Certainly not because the Germany of that time occupied an advanced position in science or in medicine; for, as a matter of fact, medically, Germany then stood at the foot of the world. Nor was it due to any superiority of Müller over Magendie as an exponent of the experimental method in medicine; for it is now generally conceded, excepting, perhaps, in Germany, that the latter made "the experimental method the corner stone of normal and pathological physiology and pharmacology" (Welch) and that "his method of work and his points of view are the ones that were subsequently adopted in physiology" (Howell). Furthermore, the progress of science up to this period proves that it was not any superior qualities of the Teutonic mind that determined Germany's part in the new growth of science. Rather it would seem that the development was more rapid, more continuous and more even there than elsewhere, unquestionably because it was an *organized* development. The state early recognized the advantages to be gained by leading the world in science, and, by establishing and supporting, generously for those times, laboratories of the medical sciences in the universities, which it owned and controlled, by offering to their medical schools the free use of their state owned hospitals for teaching and investigation, and by exercising a liberal and *laissez faire* policy in their dealings with men of science, the conditions were supplied which not alone were conducive to scientific investigation but also attracted into university careers those best able to contribute by investigation to the advance of medicine.

The world's history affords numerous examples of a comparable influence of far-seeing monarchical aid upon the advance of science. The first gleam of organized science in the world (Wells) shone from the Lyceum at Athens where a liberal endowment by Alexander the Great put Aristotle in a position to make a comprehensive collection of material to serve as a basis of his natural history. Again, the professors and fellows of the Museum at Alexandria were appointed and paid by the Ptolemys (Wells) and when their patronage ceased its scientific energies became extinct. And into Russia anatomy, then practically the comprehensive medical science, was forced by the arbitrary will of Peter the Great when he founded a medico-surgical school at Petrograd and left plans for the establishment of the Academy of Science where anatomy has since been cultivated, under very satisfactory conditions, by some of the greatest of its students (Bardeen).

Surrounded by the very best of working conditions, with an almost virgin field to work in, Germany needed only the time necessary to imbue its student body with the spirit and the possibilities in order to gain the ascendency in medical science. Workshops for different sets of problems, physiological, biochemical, pathological, pharmacological, hygienic, with professional workers in charge, gradually re-

placed the private laboratories that were usually conducted merely to satisfy an avocation. The pupils of Müller and their contemporaries, in charge of these laboratories, soon attracted to them the attention of the world, and medical students flocked to work in them as they once had to Italy during the revival there.

Though the spread of modern scientific medicine for the most part can thus be traced either directly or indirectly from Germany, sight should not be lost of the fact that in all of the more enlightened countries of the world the spark of independent genius has ever continued to add by its own methods to the realm of knowledge. There never has been a more brilliant worker in physiology than Claude Bernard, the pupil and successor of Magendie; and 'the story of the rapid sequence of Pasteur's brilliant discoveries in science ever of crucial importance and establishing a new principle, has . . . . . no parallel in biology, or, for that matter, any other science" (Pearce). Furthermore, though the start was made in Germany, in some localities the transplanted method has led to a growth that has been quite as splendid as in the land of its original cultivation. This is true, for example, of the development of physiology in England (Hopkins).

In the United States, with which the rest of this paper deals, a beginning was made in medical science before the dawn of the classical period of the modern development in Germany, and the start was quite auspicious. Just before the American Revolution medical schools began to be founded in connection with universities; with the College of Philadelphia in 1765; with King's College in 1768; and somewhat later with Harvard, 1783; Dartmouth, 1798, Yale, 1810, and Transylvania, 1817. The model of these schools was the medical department of the University of Edinburgh, which in turn represented a development of the idea of the great Italian universities, handed down through the Dutch university of Leyden (Welch).

These schools were founded by men who had received their training mainly in the proprietary schools of London and in the University of Edinburgh. Of the medical sciences descriptive anatomy alone was cultivated. Apparently the contact which many of the teachers in these schools had had with that master of experimentation, John Hunter, and with Charles Bell failed to transmit the spark; for they contributed nothing to the development of experimental medicine. The reason for this seems to have been that whatever of the scientific spirit these pioneer university schools may have had was soon crushed out through competition with the great crop of private schools of anatomy and of proprietary schools of medicine that grew up about them. In the absence of any guiding spirit practically all schools became commercial enterprises, conducted rather for the professional reputation and pecuniary benefit of their faculties than with a view to training good physicians or to advancing the science of medicine. There were, to be sure, exceptions to this rule. Some proprietary schools were founded by high minded men and were maintained for the purpose of supplying well trained physicians to a rapidly expanding country which was neither rich enough nor settled enough to support university schools properly so called. An outstanding example was the so-called Medical Fund Society, the holding corporation of the St. Louis Medical College, now the Washington University School of Medicine, through whose devotion and self sacrifice the St. Louis Medical College eventually came to be supplied with a permanent endowment, and was enabled to become one of the first medical schools west of the Atlantic seaboard to establish a scientific laboratory (under W. T. Porter in 1886). But even the more ethical of these schools, dependent, as they were, almost entirely upon fees from students, failed to supply the elements that are necessary to lead any but a self sacrificing genius to interest himself in and devote himself to medical science.

In consequence of these conditions, following the American Revolution and for a period of almost 100 years medical science in the United States rather receded than advanced. Excepting certain individual and for the most part casual contributions, such, for example, as those by Beaumont, made in the back woods

and despite every kind of obstacle, and those by S. Weir Mitchell, both entirely American trained, nothing was accomplished toward the development of the science. It should be added, though, that both Beaumont and Mitchell were influenced to some extent by the progress in Europe. Interesting proof of this is found in the marginal annotations in Beaumont's private copy of Magendie's "Summary of Physiology," now a part of the Beaumont collection in the library of the Washington University School of Medicine.

It is clear, then, that the more enlightened of the American profession were not unfamiliar with European progress in medical science. Many of them indeed had been abroad, attracted mainly to the France of the early nineteenth century by her prowess in clinical medicine. But, with the exception of Spain and possibly one or two of the smaller European states, the United States has been the slowest of the enlightened nations of the world to participate in the scientific productivity of the modern era. For this tardiness a number of factors seem to have been responsible. One of them, the main one, viz., the low estate of medical education of the time, has been mentioned. It is possible that preoccupation with the affairs of a rapidly expanding country, which gave little opportunity for leisure, and the distractions centering around the attempts to settle the institution of slavery, culminating in the Civil War just about at the time the peak of the progress in Europe was being reached, also were factors. The influence of the Civil War in retarding progress is indicated by the history of the first laboratory for experimental medical research to be established on this side of the water. Henry P. Bowditch had just been graduated from Harvard College when the Civil War broke out. Upon resigning from the army at the close of the war he took up the study of medicine, graduating in 1868, and then went abroad, where he worked in the laboratory of Claude Bernard, but especially in that of Carl Ludwig. Immediately upon his return to this country in 1871 he created the physiological laboratory at Harvard. In the same year, it might be added, Harvard instituted laboratory instruction, though not research, in histology and pathology.

Five years elapsed before any further progress in this direction was made. Then, in 1876, through the wise use of an opportunity to make a wholly new start, there was established the first institution in the country, the Johns Hopkins University, to raise productive scholarship in all of its departments to the plane it occupied in European universities. Newell Martin, Michael Foster's assistant at Cambridge, primarily a physiologist, was called from England to fill the chair in biology. From this laboratory and from the laboratory established at Harvard a considerable number of physiologists and experimental biologists have since gone forth, and through the incentive of these two institutions physiological laboratories were established in quick succession in the more progressive of the medical schools of the country.

Without running through the gamut of the laboratories of the medical sciences that were then established, it may be stated merely that in the period extending from the introduction of the scientific spirit into the study of medicine at Harvard in 1871 down to the beginning of the present century the more advanced of the medical schools and especially those connected with universities voluntarily filled their chairs with men who were drawn into the work by the spirit of research and who looked forward hopefully to the future of their profession in their country. To this natural development of the medical sciences there has more recently been added a forced and rapid growth, the result of propaganda for the elevation of standards conducted by the Council of Medical Education of the American Medical Association, by the Association of American Medical Colleges, and by the General Education Board through their reports on the status of medical education made by Flexner, and through the elevation by State Boards of Medical Examiners of the requirements for admission to practice. Along with this development of science departments, there has occurred a great increase of interest in what has come to be called the science of clinical medicine, which Meltzer, its first exponent in

the United States, has defined as the "science of the natural history of diseases, their physiology and the pharmacology." Contributions to this phase of medicine until quite recently had been made almost solely by clinicians in such time as they could snatch from teaching and practice. Through the organization of clinical departments, in some schools, upon the same basis as the preclinical departments there is now an opportunity open to men so inclined to devote themselves wholly to the advancement of the science of clinical medicine. Other recent developments have consisted in the establishment of research laboratories in connection with a few of the better hospitals and in the foundation of medical research institutions both in connection with and independent of universities.

This tremendous growth in the number of full time laboratories of medical science has necessitated a corresponding increase in the number of men devoting themselves to the subject. I am sure that something of interest would come of a careful study of the rate with which this increase has occurred; but the information necessary to accomplish it satisfactorily is not at hand, and even if it were, far more time would be required to make it than I have had at my disposal. But I do happen to have some data bearing on the rate of increase in the membership of the American Physiological Society. Starting in 1887 with a charter membership of 28, the membership in 1896 amounted to only 68, but by 1921 had increased to 292. If to this be added the membership of the societies that have grown out of the Physiological Society, namely the societies for biochemistry, formed in 1906, for pharmacology in 1908, and for experimental pathology in 1913, the total membership excluding duplicates now amounts to 469. These figures give some idea of the rapidity of the development during the present century. In order to gain some idea of the number of men now devoting themselves to the science of medicine, I have had an estimate made of the medical scientists exclusive of those following "medicine" and "surgery" listed in American Men of Science; conservatively the total is in the vicinity of 1,200. And in order to gain some notion of the number of these connected with medical schools supporting full time laboratory departments it has been assumed, again conservatively, that in each of the 68 Class A schools there are 10 full time men devoting themselves to medical science, or a total of 680.

The first journal to be published in America to serve primarily as an outlet for research in the medical sciences was the *Journal of Morphology,* which began its career in 1887; and the first journal devoted to experimental medical science, the *Journal of Experimental Medicine,* appeared in 1896. Then to care for the increase in the volume of research conducted by the greatly augmented personnel came in fairly rapid succession special journals devoted to physiology, 1898, to anatomy, 1900, to biochemistry, 1905, to pharmacology, 1907, etc., etc., so that now there are some 17 titles devoted practically exclusively to the medical sciences. In the same period there has also been an increase in the number of journals devoted to clinical science. Owing, however, to the difficulty of distinguishing between those maintaining a high scientific standard and those less particular in the quality of the papers accepted for publication, it is difficult to estimate accurately the development in this direction.

The increase in journal titles does not exactly parallel the increase in the volume of published work; for there has been in some cases an increase in the number of volumes issued per year and often also an increase in the size of the volume. Furthermore, prior to the publication of American science journals a certain number of scientific papers which would have found a place in them appeared in the clinical journals, a certain number also were sent to foreign periodicals for publication. However this may be, a rough estimate of the volume of work now published may be formed merely by counting the number of volumes issued by the American journal, exclusive of the clinical journals, during the year 1920. This totalled 35.

Viewed in the abstract, the tremendous increase in the number of work shops of the medical sciences, in the band of workers and in the volume of their published work that has

occurred in the United States during the course of the fifty years that have elapsed since cognizance was first taken on this side of the water of the existence of a science of medicine, might be regarded by some as sufficient grounds for a feeling of complacency on our part. But after all, such matters are largely relative; accomplishment in these directions can be gauged only by comparison with what has been and is being done elsewhere. Before assuming a self-satisfied attitude it would be well to make a few inquiries: "Are we doing as much work in medical science as the number of men engaged ought to accomplish?" "Does the United States occupy in the realm of medical science the position it now holds in the political and commercial world?" "Are we doing as much as a country should which stands first in point of wealth and first amongst the western nations, with the exception of disorganized Russia, in point of population?" But above all, "How does the quality of the work we are doing measure up with that which is being done elsewhere?" In a material way the United States is one of the first countries in the world; what is her position in the realm of medical science?

Satisfactory answers to these questions can be obtained only by providing some standard for comparison. Without making any apologies, and for reasons which will become clear as we proceed, we propose to compare our accomplishment with that of Germany. It has been stated that there are in the United States at the present time at least twelve hundred men devoting themselves to preclinical science. Comparable data relative to Germany are not available. We do know, however, that in 1921 in her 22 medical schools there was a total of 312 full time men in the departments of the preclinical sciences, to which for our purposes might be added the number of full time preclinical instructors in the three medical schools of German Austria, bringing the total to 387 (compiled from Minerva). It was stated above that 35 volumes of medical research are now published annually in the United States in 17 journals. This is the product of the labor of approximately 1,200 men, some 680 of whom are connected with medical schools. Germany publishes 44 journals of similar scope and comparable as regards standards with the 17 of the United States, the total of volumes amounting to 72. There is no convenient way of ascertaining the number of professional men of science contributing to the German journals for the reason that they cater not alone to Germany and to Austria but also, to a certain extent, to some of the other European states that have no media for their own papers. It seems rather unlikely, though, in view of the ratio of the number of university instructors in Germany to the number of university instructors in the United States as computed above, that the number of professional contributors to German periodicals exceeds the number of professional scientists in the United States.

But even if it were true that the volume of scientific work in the United States has increased to the point of equaling that produced by Germans, it is not the amount of productive scholarship that counts, but its quality. It is just here that judgment becomes difficult. Individual opinion on a question of comparative merit is worth but little. Of somewhat greater value is the judgment of world courts, but even these are not infallible judges. Bearing this in mind, let us review the findings of foreign academies and of the Nobel Prize Commission. In 1909 Pickering found that of the 87 scientific men who were members of at least two foreign academies only 6 were American as compared with 17 from Prussia, 13 from England and 12 from France. To be sure this exhibit is of the fruit of a generation ago; it is possible, furthermore, that this disproportion no longer obtains. Indeed, news reports would seem to indicate that during the past two or three years a considerable number of Americans have been the recipients of foreign honors. While to a certain degree this new movement may be the result of a tardy recognition of scientific achievement, there is no doubt but that diplomacy also enters as a factor. So even if present figures should be found to be less disproportionate, it might be safer to accept the decision of the earlier ratio than that which a

new statistical study might reveal. These difficulties do not apply, not at least in the same degree, in the case of the awards by the Nobel Prize Commission. There have been in all 18 awards of the prize for eminence in medical science. Four times it has gone to Germany and once it has come to America. And it may not be entirely irrelevant to our theme to add that the recipient in America is foreign born and foreign trained.

Accepting this verdict of the world on the quality of medical research in the United States it behooves us to search for the causes of our shortcomings in the hope that a way to improvement may be found. The first thought the situation raises is that our failure to measure up favorably in productive scholarship with the best that has been accomplished elsewhere possibly is to be ascribed to the recentness of our entrance into the field. This is scarcely possible. Germany required the time of but one generation to acquire her pace. We are now well along in the second generation, almost indeed, at the beginning of the third, and while, as has been said, we have developed more workshops and more posts than now exist in Germany, not alone have we not caught up with her, but she seems still to be gaining on us, though perhaps at a diminishing rate. By way of illustration we need to refer only to the 19 new journals of medical sciences which she has launched in the last 20 years, in comparison with our 15.

No, the difference in our relative positions continues to exist not because of the tardiness of the manifestation of our interest in medical science, but for several reasons of which the first consists in our failure as yet to provide sufficiently or sufficiently generally, the ideal academic relations both material and personal which the German government could and did supply from the very beginning, and which, as has been pointed out, made possible her phenomenal start. To further embarrass the healthy development of medical science in the United States new conditions have developed which I would not presume to mention were it not for the importance attributed to them in so many of the statements submitted to the committee on pre-clinical assistants. Due to the rapid, in part forced, spread of the medical sciences through the professional schools of the country, for which but few could make adequate provision; due further, to a depreciation in the purchasing power of money, more rapid than the advancing scale of emoluments, which were rather meager even at the beginning, aggravated by a concomitant elevation of the general scale of living permitted by industrial prosperity; and due to the establishment of university clinical departments upon endowments permitting a more adequate support than is possible in any preclinical department; due to all of these and to other factors to be mentioned later, it is becoming increasingly difficult for preclinical departments to secure recruits of any kind, let alone recruits who have given evidence, or even promise, of being able to make noteworthy contributions to the advancement of science. In some quarters the view is held that these conditions are merely temporary and consequent upon the war. As a matter of fact, however, they were beginning to make themselves felt years before, and not alone in this country but in Germany even. In 1911 Barker writes, "when the financial rewards of most of the lines in medicine are distinctly alluring, only a vein of eccentricity or idealism can induce a young man of ability to enter a career which assures a comfortable living for but a few fortunate leaders"; while Abraham Flexner in 1912 states that "assistants are scarcer (in Germany) than formerly when the deprivations attendant on a scientific career were less deterrent than they now appear to be." The investigation carried out by the National Research Council in 1920 demonstrated unmistakably that the scientists themselves now regard the situation just as did the clinician and the educator ten years ago. I have been told that after reading the report of the National Research Council a certain financier, presumably a university trustee, concluded from the statements of departmental heads quoted therein that university men had lost their idealism. Be this as it may, it is futile to deny that scientific men are any less, or

ever have been any less, under the influence of the incentives which spur on human beings in general to give of the best that is in them. These incentives are the opportunity for achievement—achievement of worldly goods, achievement of position or achievement of fame. Under any circumstances there must be provided for men entering scientific careers an opportunity to gain by their own efforts the prerogatives and comforts which now can be acquired in other walks of life by any one of similar attainments who meets with a fair degree of success. Position in the scientific world can be attained only through scientific accomplishment and, innate ability aside, its attainment depends in large degree upon the provision of certain conditions, amongst which may be mentioned freedom of action, opportunities for research and often a certain, though not excessive, contact with students. It may not be superfluous to state that medical scientists have been known to decline at great financial sacrifice proffers from institutions of excellent repute but which were not in a position to supply the last only of the conditions just outlined. It can not be denied, however, that the financial incentive seems to be gaining in importance. And the reason seems to be that in times like the present, when fundamental discoveries are rather infrequently made and scientific achievement therefore is relatively slow, the hope of gaining distinction as an investigator alone is not sufficiently strong to induce assistants to put up with "the deprivations attendant on a scientific career." It is as true now as when Cannon stated it in 1911, that "the satisfactions of a life devoted to investigation like the satisfactions of other careers, arise from a profitable use of one's powers."

The recent movement to increase the support of clinical departments which in some places includes putting them on a full university basis, has had the effect of adding still further to the difficulty of the preclinical departments in securing assistants. In the physiological, the chemical and the biological divisions of the clinics men who desire them are given opportunities to devote themselves to any branch of medical science and at salaries usually in excess of those paid preclinical investigators in the same stage of advancement. These posts do not, as do the preclinical posts, preclude contact with clinical medicine; it therefore happens that incumbents in the former may at one and the same time, fit themselves for university careers or to step out into practice. It is obvious under these circumstances that such departments rather than the preclinical departments will have first choice of any such men as may wish to devote themselves to experimental medicine. The so-called full time movement unquestionably is a step in the right direction. But unless the disparity in compensation be removed, and unless, in general, appointments to the science posts in the clinical departments be conditioned, as they logically should, upon an apprenticeship in the preclinical department of the subject which later is to have the candidate's attention in the clinic, the fundamental departments will be ruined and will drag down clinical science with them.

This brings us to the last of the difficulties we desire to discuss which stand in the way of a healthy development of medical science in the United States. It is obvious that in so far as departments are inadequately provided for and that in so far as able men cannot be induced to take up preclinical science as a career, these conditions in turn will stand in the way of securing strong men. "If a department has a professor, an assistant professor and several instructors who are well trained, active investigators, they by contact with the students are able to interest them in investigation and thus increase their chances of becoming permanently attached to investigation as a pursuit. Just because we have an inadequate or ill qualified personnel we continue to have such a personnel."

It seems clear then that the United States is not accomplishing all that it should toward the advancement of medical science; that in part this is due to the absence of that complete fusion of hospital with the research laboratory, that permits the free transfer of problems from laboratory to hospital and from

hospital to laboratory, but in larger part to a failure to provide in sufficient measure those conditions that serve to attract able thinkers and men of action to the work. One can not in this connection avoid asking as to whether or not the American mind really possesses the qualities that make for scientific acumen. There can be no question but that it does. If proof of this is needed it is furnished by the development of astronomy in the United States. Astronomy is a science that appeals strongly to the popular mind and on that account early won the support of American philanthropies. That this confidence was not misplaced is indicated by Pickering's figures which show that of the six American men of science who, as has been said, are members of two or more foreign scientific academies, three, or one-half the number, are astronomers. If Americans can become prominent in astronomy, why not in medical science also?

In explanation of the present difficulties it has been suggested that we are not providing a suitable course of training for those who otherwise are adapted to a career in medical science. This is entirely aside from the subject discussed above of the quality of present day teachers. The training calculated to give the best preparation for the pursuit of medical science is so different for the several sciences that within the limits of this paper it will be possible to discuss the subject in general terms only. In preparation for any of the sciences, with the possible exception of pathology, the training may be either medical or philosophical. In most of our better universities, either of these preparations may be and has been pursued, with the result that there are today in the chairs of our more prominent laboratories of physiology, for example, almost as many doctors of philosophy as doctors of medicine. There is nothing obvious in the careers of the two groups thus differently trained that leads to the conclusion that one set has had any decided advantage over the other. To be sure, those entering the field of preclinical science through the medical gateway, are less apt to have received instruction in physical chemistry or in advanced mathematics and physics, subjects which are helpful in all types of experimental work, especially in physiology. But at the risk of making a trite remark, it may be said that training does not end upon the receipt of a degree. All of us in the course of our careers have seen young men of talent rise to the occasion and acquire the mathematics or the physics, or what not, that happened to be necessary to provide them with the power to solve the problems of their choosing. It seems obvious, therefore, that it is more the quality of the brain than any particular training that makes for success in investigation.

In connection with the establishment of research laboratories for physiology, chemistry, biology, etc., manned by full time investigators, in direct connection with the clinics, the question of the advisability of a division of labor has arisen. At one extreme it has been maintained (Cole) that these clinical laboratories must be complete in every detail, and absolutely independent of the departments of the "contributing sciences"—"anatomy, physiology and pharmacology" though if necessary "to give advice . . . . specialists in the various branches of science can always be *employed* (italics mine) . . . . to give advice"; while at the other extreme are those (Henderson) who feel that these clinical laboratories should be in direct charge of the fundamental departments after which they are named. It would seem, however, that the best policy to pursue is not to adopt any particular system, but merely to provide equal opportunities for the two groups of workers, one interested primarily in the fundaments, the other in their clinical applications. Neither group should nor would be debarred from poaching on the other's domains; there is no devotee to pure science who knowingly would fail to at least point out any practical application of the results of his investigations; neither should a clinical scientist be frowned upon if perchance his research should lead him into the realm of general principles. But in general, and in the interests of a helpful division of labor, a full time surgeon, for instance, would be expected to devote himself to surgery, per-

fecting himself first in the technique of diagnosis and treatment of surgical conditions and then, in his laboratory, concerning himself with the development of methods of surgical diagnosis and treatment. In other words, the surgeon ordinarily devotes himself to surgery, just as the physiologist ordinarily devotes himself to physiology. When border line work is undertaken there should be provided an opportunity for cooperation between departments either by means of direct help or through advice.

In the development of our theme it has been furthest from our intention to give the impression that the effort made in the United States to contribute to medical science has been futile; as a matter of fact, we are now accomplishing as much as a great many other countries. But it is clear that we are not doing as much as we should and our purpose has been to ascertain the causes of our backwardness in the hope of pointing the way to their removal. In Germany, it has been seen, the ascendancy was gained through wise action of a paternal form of government in supplying the conditions that are most conducive to securing *men*. In a democracy, such as the United States, the same end can be gained only by the much slower process of education. Not alone is it necessary to obtain the interest of men capable of supplying brains for the development of medical science, it is equally necessary to educate the enlightened public up to the point of understanding that just as in the case of astronomy, or of physics, or of chemistry, it is only by the diligent employment of the scientific method that progress is possible; that by that method alone will an understanding ever be gained of the manner in which the human body functions in health and disease. The adoption of the designation "Medical Science" for this division of the American Association and for what formerly was the "Medical Division" of the National Research Council is taken to indicate that the value of science in medicine is coming to be appreciated by scientific men and presages a recognition of its worth by the enlightened public at, let us hope, not too remote a date. When that has come about, and not until then, will medical science in the United States come into its own.

But is the goal still worth fighting for? Is it possible, to quote Herter, that the "golden nuggets that are near the surface of things have been for the most part discovered?" In a general sense this figure unquestionably represents conditions as they now are. It is incomplete, however, in that it applies only to the working of claims already staked out, and fails to allow for the possibility that venturesome spirits from time to time may succeed in opening up new territories in which surface mining may again bring forth rich yields. And it fails to allow for the possibility of an improvement in machinery which may make deep mining as profitable as placer mining. Great as is the headway that has been made, it does not require a very intimate acquaintance with medicine to realize that such unopened domains still exist. But whatever the future may have in store for us we must, I think, in the interests of progress, if for no other reason, maintain that a way will be found by which to explore them. One has only to recall in this connection the remarkable development of the sciences of bacteriology and immunology that has occurred in a little over one generation; or, to go outside of medicine, to consider the revelations in radio activity in our own time and the remarkable influence they have had upon our fundamental conceptions of matter and force, conceptions which have as yet scarcely made themselves felt in medicine, in order to realize that there still must be plenty of opportunity for revelations in medical science if only it could be recruited with master minds capable of reading the signs which still elude us. If the United States is to supply her share of the progress that is to come a way will have to be found of bringing into the field of medical science the talents which, in the opinion of those best able to judge, are most likely to see the light.

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